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# PATENT ABSTRACTS OF JAPAN

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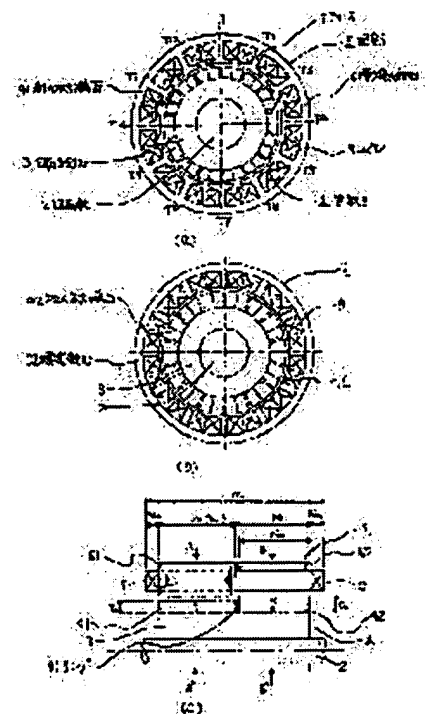
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## (54) PERMANENT MAGNET TYPE SYNCHRONOUS MOTOR

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To reduce the torque ripple of a permanent magnet type synchronous motor, reduce the copper loss, improve the performance of the motor and, further, facilitate the winding work.

**SOLUTION:** A motor consists of a stator 5 which is composed of an armature core 61, a plurality of teeth 7 which are formed on one side of the armature core 61 in the direction of a transfer magnetic field with same intervals and coils 8 wound on the teeth 7 and a rotor which is composed of multipole permanent magnets 41 and 42 which face each other with an air gap therebetween. The teeth 7 are formed on the armature core 61 partially in its width direction, and the coils 8 are formed over the full width of the armature core 61. As for the tooth 7, the straight tooth 7 without a pole shoe or the tooth 7 with a pole shoe may be used. In the latter case, the rotor surface which faces the inner side part of the coils 8 in which the teeth 7 are not inserted is higher than the rotor surface which faces the tips of the teeth 7.



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CLAIMS

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[Claim(s)]

[Claim 1] An armature core Two or more teeth formed in the piece side of this armature core at equal intervals in the direction of shifting magnetic field A stator which consists of a coil wound around these teeth A needle which fixed a multipolar permanent magnet which meets through said teeth and air gap It is the permanent magnet form synchronous motor equipped with the above, and said teeth are formed in a part of width of face of said armature core, and it is characterized by rolling said coil to the limit of width of face of said armature core.

[Claim 2] Teeth formed in an armature core are permanent magnet form synchronous motors according to claim 1 characterized by being straight.

[Claim 3] A permanent magnet of a needle with which teeth formed in an armature core meet a coil of a portion with which teeth are not inserted while a pole shoe is formed at a head is a permanent magnet form synchronous motor according to claim 1 characterized by being thicker than a permanent magnet of a needle which meets at said head of teeth, and being high simultaneously.

[Claim 4] Teeth formed in an armature core are permanent magnet form synchronous motors according to claim 1 characterized by a pole shoe of the magnetic substance fixing in accordance with a magnetic pole into a portion which meets a coil of a portion with which said teeth are not inserted among front faces of a permanent magnet of a needle with which thickness was fixed with a needle and carried out the shape of a cylinder while a pole shoe was formed at a head.

[Claim 5] Claim 1 characterized by an air gap being the motor of nothing and a revolution form about the shape of a cylinder thru/or a permanent magnet form synchronous motor given in four.

[Claim 6] Claim 1 characterized by an air gap being a nothing and linear motor about a plane thru/or a permanent magnet form synchronous motor given in four.

[0001]

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DETAILED DESCRIPTION

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## [Detailed Description of the Invention]

[The technical field to which invention belongs] The high engine performance is called for by precision, speed, and responsibility among the motors used for semiconductor fabrication machines and equipment or FA device, and this invention relates to the synchronous motor of a ripple or the permanent magnet form where loss is small.

[0002]

[Description of the Prior Art] If a permanent magnet is used for a motor, acquiring high torque is known for the compact configuration, and the thing of various structures is considered. A common synchronous motor equips a rotator with a permanent magnet, winds a coil around the armature core of a stator, and is constituted. However, it had become a problem that it also increases iron loss and cogging torque although this structure can make torque high by the end of today when the permanent magnet of high performance is being developed. In order to solve this, what has improved how to roll a coil is developed and it is indicated by JP,63-154051,A. This technology is explained using drawing. Drawing 5 is the positive cross section of the conventional permanent magnet form synchronous motor, and drawing 6 is coil gestalt drawing of the coil of a stator. This motor is a permanent magnet form synchronous motor of three-phase-circuit 6 pole, and the number of slots of \*\*\*\*\* has become 1. Therefore, 18 slot #1-#18 are formed in the hoop direction at equal intervals in the armature core 65. If the coil wound around this takes for an example one coil which has the bottom coil side 82 and the top coil side 83, the bottom coil side 82 will be laid under the bottom in slot #16, and the top coil side 83 will be laid under the slot #1 upside of 3 right. In the case of another coil which has the bottom coil side 84 and the top coil side 85, it is laid under the bottom in slot #1, and the bottom coil side 84 is laid under the slot #4 upside of 3 right, the coil of the same configuration adopts the same way of winding, a series connection is laid underground and carried out to other slots, and the top coil side 85 is making the coil of U phase. The coil of V phase and the coil of W phase also carry out the same method of a volume as the coil of U phase, are wound, and are laid under the slot shifted one piece. The connection method is selected if needed and let the coil of this three phase circuit be a three-phase-circuit motor. As shown in drawing 5, six permanent magnets 46 have fixed on the front face of the axis of rotation 21, and it is magnetized by the rotator of this synchronous motor so that the polarity of an adjacent permanent magnet may differ.

[0003]

[Problem(s) to be Solved by the Invention] However, according to the aforementioned conventional technology, there were the following problems. That is, since it was united with the bottom coil side of another side which each coil top coil side is arranged in an air gap, and is laid under the slot, it was not easy for a coil end to interfere with the coil end of other coils, and to constitute a predetermined coil. Moreover, though the top coil side and the bottom coil sides are some same coils, since a cross-section configuration crossed, when carrying out a coil, there was a defect that workability was very bad, with positioning. Furthermore, since this activity was needed, when the location of the coil wound around the air gap tended to stop having gathered and a motor was driven, the torque ripple occurred, and there was a problem of bringing various evils to a drive system-ed -- a revolution ripple arising. In order to improve the aforementioned workability, when the coil end was lengthened, the copper loss of a coil will increase, the effectiveness of a motor will fall, and it had to make into the sacrifice any of workability and effectiveness to be. Thus, there are various evils which the conventional coil winds and originate in the location of a coil in the direction, and it had become a problem.

[0004]

[Means for Solving the Problem] This invention is made in order to cancel these defects, high engine performance is obtained by precision, speed, and responsibility, and it aims at offering a ripple and a synchronous motor of a permanent magnet form where loss is small. Then, two or more teeth by which this invention was formed at equal intervals in the piece side of an armature core and this armature core in the direction of shifting magnetic field, In a

permanent magnet form synchronous motor which consists of a stator which consists of a coil wound around these teeth, and a needle which fixed a multipolar permanent magnet which meets through said teeth and air gap. Said teeth were formed in a part of width of face of said armature core, and rolled said coil to the limit of width of face of said armature core. If it carries out to whether teeth formed in an armature core consider as a straight thing, or a pole shoe is formed at a head and is in the latter or [ a permanent magnet of a needle which meets a coil with which teeth are not inserted being thicker than a permanent magnet of a needle which meets at the head of teeth, and making it high simultaneously ] -- or Thickness was fixed and a pole shoe of the magnetic substance was fixed in accordance with a magnetic pole into a portion which meets a coil with which teeth are not inserted among front faces of a permanent magnet of a needle which carried out the shape of a cylinder. Moreover, said permanent magnet form synchronous motor was used as a permanent magnet form synchronous motor of a revolution form so that an air gap might become cylindrical, or it considered as a linear permanent magnet form synchronous motor so that an air gap might serve as a plane.

[0005]

[Embodiment of the Invention] If it does in this way, since it becomes easy, and a coil activity will position a coil with a sufficient precision, can fix now and can also shorten a coil end, the motor of efficient and high degree of accuracy can be offered by low cost. Hereafter, the gestalt of operation of this invention is explained based on drawing. Drawing 1 is the cross section of the permanent magnet form synchronous motor of the revolution form which shows the 1st example of this invention, and a positive cross section and (c of (a) and (b)) are axial sectional views. Moreover, (a) is the cross section of an A-A' side of (c), and (b) is the cross section of a B-B' side of (c). Drawing 2 is coil gestalt drawing of the coil. In drawing 1, 1 is a rotator and consists of a rotor core 3 of the axis of rotation 2 supported pivotable by the bearing which is not illustrated, and the magnetic substance which fixed on the periphery of this axis of rotation 2, and the 1st permanent magnet 41 which has two or more magnetic poles in hoop direction regular intervals, and fixed on the periphery of said rotor core 3, the 2nd permanent magnet 42 and the nonmagnetic ring 91. There is a nonmagnetic ring 91 in the center of shaft orientations of a rotor core 3, it is inserted between the 1st permanent magnet 41 and the 2nd permanent magnet 42, and the outer diameter of the 2nd permanent magnet 42 is larger than the outer diameter of the 1st permanent magnet 41. The 1st permanent magnet 41 and 2nd permanent magnet 42 have the magnetic pole of 14 in a hoop direction, it is magnetized in the direction of a path, and the location of the magnetic pole of a hoop direction is the same with the 1st permanent magnet 41 and 2nd permanent magnet 42. In addition, although the direction of magnetization is the direction of a path in this example, it does not matter at all if the magnetic pole of 14 is formed in a hoop direction, even if it will be magnetized by the hoop direction.

[0006] 5 is a stator and consists of the armature core 61 of the magnetic substance which formed teeth 7 in the bore side of a cylinder-like iron core, an endless core 62 where the iron core of the shape of a cylinder of an armature core 61 was extended and formed in shaft orientations, and a coil 8 wound around teeth 7. The armature core 61 and the endless core 62 carried out the laminating of the silicon steel, and have fixed to one. Teeth 7 are formed in 12 hoop direction regular intervals, a pole shoe is formed at a head, and the coil 8 is wound. As a coil 8 is shown in (c), teeth 7 are inserted in inside [ a part of ], and the concentration volume of the part which remains is carried out so that it may become an air core. The head and the 1st permanent magnet 41 of teeth 7 have met through a cylinder-like air gap, and the coil 8 and the 2nd permanent magnet 42 which are inside an endless core 62 have met through a cylinder-like air gap. The connection condition of the coil wound around 12 teeth is shown in coil gestalt drawing of drawing 2. The coil of U phase is wound and connected to teeth T1, T2, T7, and T8 in the direction of drawing 2. It has U and a neutral terminal, the coil of V phase is wound and connected to teeth T5, T6, T11, and T12 in the direction of drawing 2, and it has V and a neutral terminal, and it winds and connects with teeth T9 and T10, T3, and T four in the direction of drawing 2, and the coil of W phase has W and a neutral terminal. The three-phase-circuit motor is made with such connection. And this example serves as a motor of three-phase-circuit 14 pole 12 slot, and the number of slots of \*\*\*\*\* has become two sevenths so that the above-mentioned configuration may show. If the motor of such a configuration is excited in order of U, V, and W phase, rotating magnetic field will occur clockwise and a rotator 1 will be rotated on the right. Conversely, if it excites, the left can be made to rotate a rotator 1. Since the concentration volume of the coil is carried out in the above example, while a coil activity is easy, even if it includes a coil end, compared with the conventional thing, the length of a coil is dramatically short, and the copper loss produced in a coil is small.

[0007] Next, the 2nd example of this invention is explained. Drawing 3 is the cross section of the permanent magnet form synchronous motor of the revolution form which shows the 2nd example of this invention, and a positive cross section and (c of (a) and (b)) are axial sectional views. Moreover, (a) is the cross section of an A-A' side of (c), and (b) is the cross section of a B-B' side of (c). The stator 5 of this example is the same as the 1st example, and a rotator 1 differs from the 1st example. The permanent magnet 43 which fixed on the periphery of a rotor core 3 is carrying out

the shape of a cylinder of the same length as a rotor core 3, has the magnetic pole of 14 in a hoop direction, and is magnetized by the direction of a path, or the hoop direction. On the periphery of the permanent magnet 43 which exists inside an endless core 62, 14 pole shoes 92 have fixed at the place of 14 magnetic poles of a permanent magnet 43, and the periphery is making cylindrical [ some ] on it. And the front face of the permanent magnet 43 which has not fixed the pole shoe 92, the air gap between the heads of teeth 7, and the air gap between the front face of a pole shoe 92 and the inner skin of the coil 8 inside an endless core 62 serve as the same magnitude. Actuation of the motor of such a configuration is the same as the 1st example.

[0008] Next, the 3rd example of this invention is explained. It is said that the 3rd example of this invention does not form a pole shoe at the head of teeth 7 in the 2nd example shown in the 1st example shown in drawing 1, or drawing 3. Since the coil 8 is wound around the teeth 7 which do not form a pole shoe to near a head and the head of teeth 7 and the end face of a coil 8 are located in the same cylinder side, the cross section of homogeneity is [ the permanent magnet which fixes to the rotor core 3 of a rotator 1 ] cylindrical. It cannot be overemphasized that the motor of such a configuration operates like said two examples. Although there is a case where the head of teeth 7 will project from a coil 8, from the convenience on an activity when adopting such structure, in such a case, it can respond by carrying out a rotator 1 like the 1st example or the 2nd example.

[0009] Although the example of a revolution form was described, since it is applicable also to a linear motor according to this invention, the above is explained using drawing. Drawing 4 is the cross section of the linear permanent magnet form synchronous motor in which the 4th example of this invention is shown, (a) and (b) are the cross sections of a field which met in the migration direction, and (c) is the positive cross section of the migration direction and a right-angled field. (a) is the cross section of an A-A' side of (c), and (b) is the cross section of a B-B' side of (c). In drawing, 51 is a stator, toward the migration direction, equipped right and left with the armature core 63 in which the teeth 71 of pitches [ direction / migration ] were formed, and is equipped with the common form iron core 64 which was united with the armature core 63 in the center toward the migration direction. The laminating of the silicon steel is carried out and the armature core 63 and the common form iron core 64 are united. The pole shoe is formed at the head at teeth 71, and the portion on a center 64, i.e., a common form iron core, of the coil 81 wound around the teeth 71 and 71 on either side has become an air core. The needle 11 consists of the nonmagnetic plate-like table 21, three permanent magnets 44, 45, and 44 which fixed to the down side, and a support device which is supported movable in the migration direction and which is not illustrated. A permanent magnet 44 meets through the teeth head and air gap of an armature core 63, the permanent magnet 45 has met through the air gap of the same magnitude as the coil 81 on the common form iron core 64, and said air gap, and the permanent magnet 45 is thicker than a permanent magnet 44. Permanent magnets 44 and 45 are magnetized so that polarity may be reversed in pitches [ direction / migration ], and permanent magnets 44 and 45 serve as 14 pitches per 12 pitches of teeth 71. Since it is having such structure, it has the same structure as what opened the form which the permanent magnet form synchronous motor of the revolution form of the 1st example shown in drawing 1 closed, developed, and was made into the flat surface. Therefore, the coil is rolled similarly and straight-line migration can be carried out in the migration direction by carrying out three-phase-circuit excitation. Although what formed the pole shoe at the head of teeth 71 at drawing 4, and made the permanent magnet 45 thicker than a permanent magnet 44 was shown As the modification of a revolution form showed, you may be equivalent to the location of the permanent magnet 45 of the front face as a permanent magnet of one of the same thickness, then the thing which fixes the pole shoe of the magnetic substance which is equivalent to a pole shoe 92 at the time about permanent magnets 44 and 45. Again It is the same as that of the thing of the aforementioned revolution form not to form a pole shoe at the head of teeth 71, but to make it straight.

[00010] As mentioned above, although some examples of the permanent magnet form synchronous motor of a revolution form and a plan type were described, the coil of these examples is a concentration volume, and since there is nothing acting as [ when a coil does not interfere mutually and a coil activity is done ] a failure, it can do an activity easily. Moreover, since a coil can be beforehand wound when [ without forming a pole shoe in teeth 7 and 71 ] straight, a coil activity has the advantage of becoming still easier.

[00011] the aforementioned motor -- any -- whenever -- although the number of slots of \*\*\*\*\* was 2/7, if the meaning of this invention is followed, it cannot be overemphasized that the numeric value is not limited above. Moreover, about a revolution form synchronous motor, although that by which the annulus ring-like permanent magnet was magnetized in the direction of a path was shown, even if it uses the permanent magnet of a segment which was good also as a hoop direction, replaced the direction of magnetization with the annulus ring-like permanent magnet, and was divided into plurality, it does not interfere at all.

[00012]  
[Effect of the Invention] The burden of a support device is mitigated and a life is prolonged at the same time according to this invention the following feature it is characteristic in the medium of the synchronous motor equipped with the

armature with teeth and the synchronous motor equipped with the armature without teeth, i.e., (1) cogging force, and the magnetic-attraction force are small and positioning accuracy improves, as stated above.

(2) Since the electrical time constant is small, the use which carries out a high-speed response has been turned to.

(3) The armature iron loss at the time of high-speed operation is small, and an efficient thing can be realized for the use which carries out high-speed operation.

Since the concentration volume of the coil wound around an armature can be carried out when offering the motor having \*\*\*\*, a coil activity becomes easy, productivity improves, simultaneously, the conventional coil end is eliminated, the copper loss of a coil decreases, and it is effective in improving the effectiveness of a motor. In the motor which has teeth without a pole shoe, a coil activity is still easier. Moreover, the configuration of a coil is simple, and since the coil activity is easy, it is effective in the installation precision of a coil improving and reducing the torque ripple or thrust ripple by location gap of a coil.

[00013]

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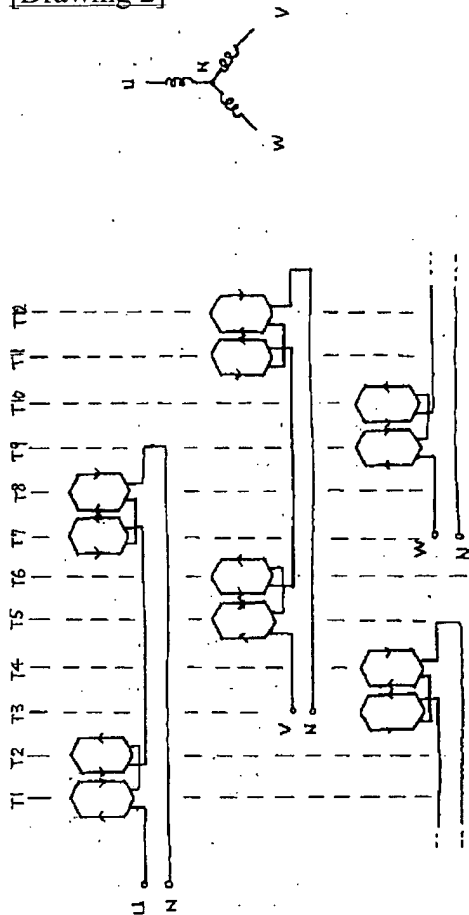
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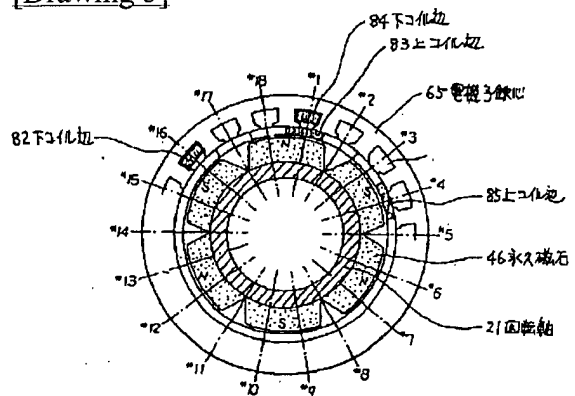
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## DRAWINGS

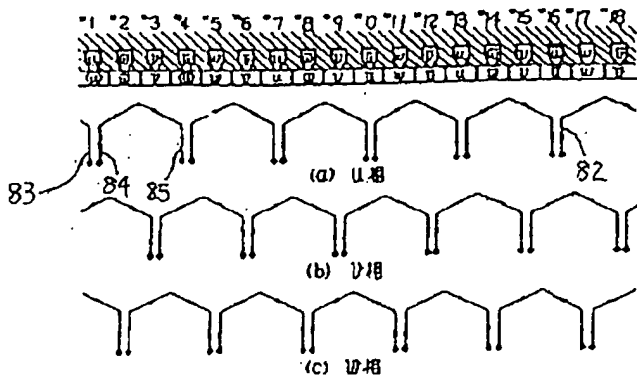
[Drawing 2]



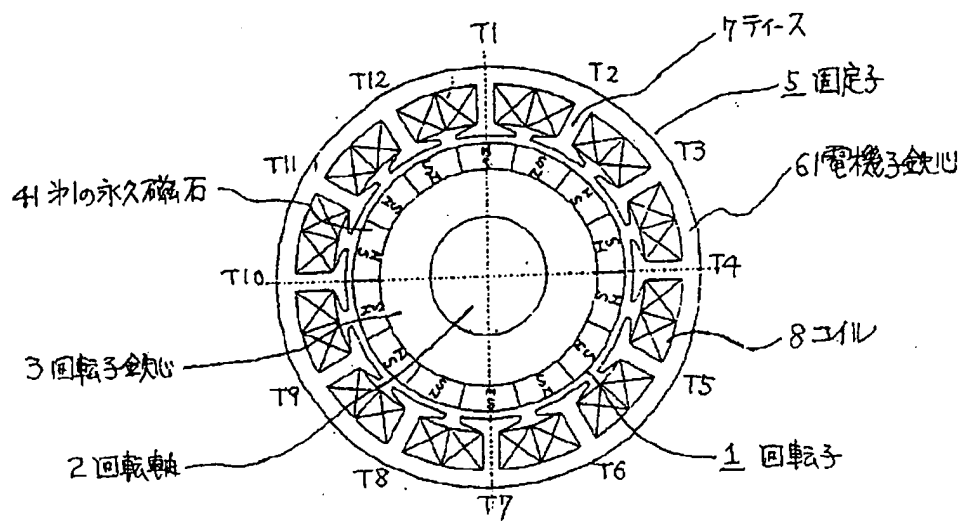
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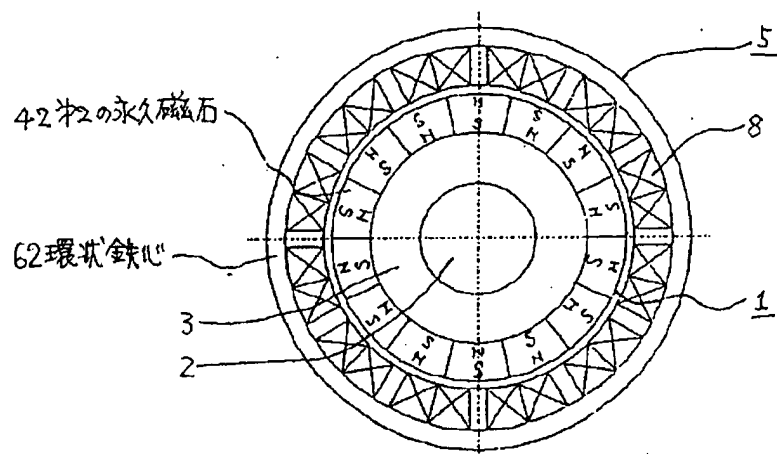
[Drawing 6]



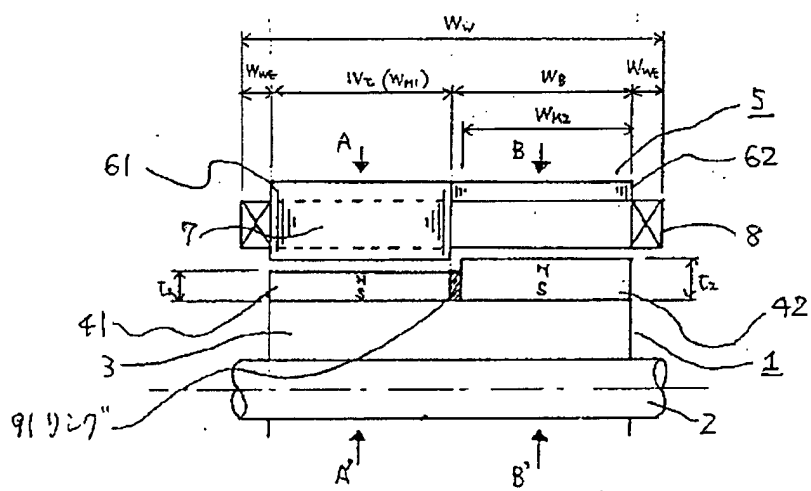
[Drawing 1]



(a) A-A' 断面図

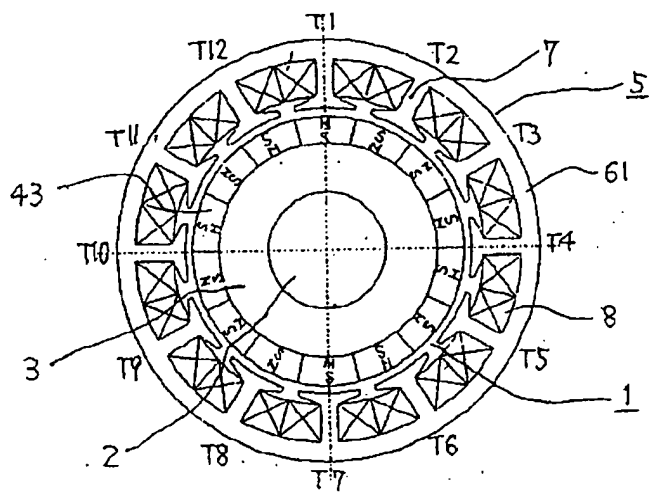


(b) B-B' 断面図

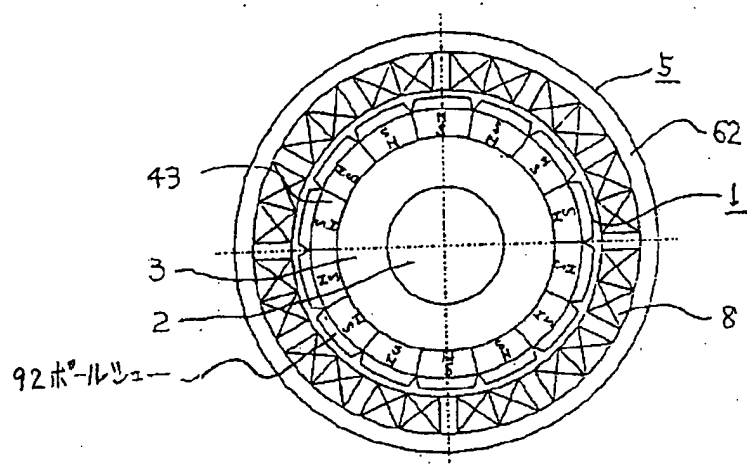


(c) 軸方向断面図

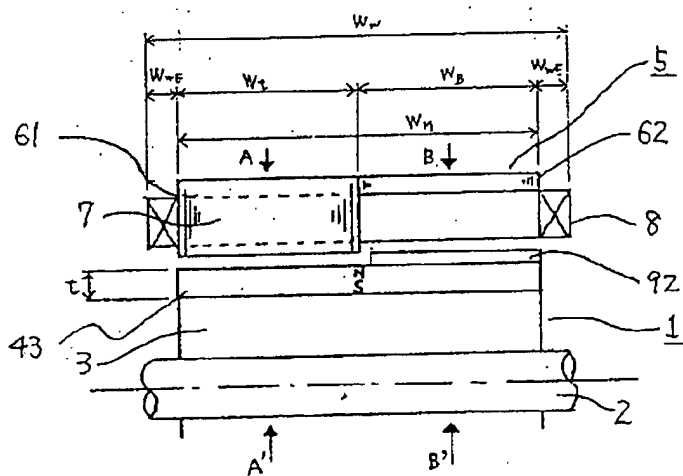
[Drawing 3]



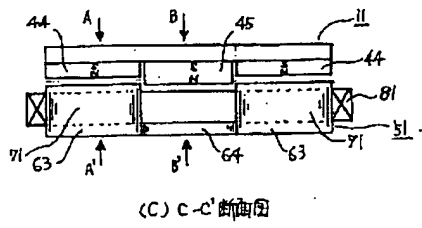
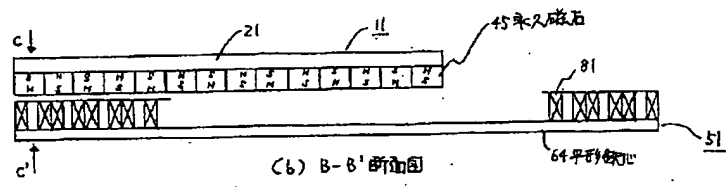
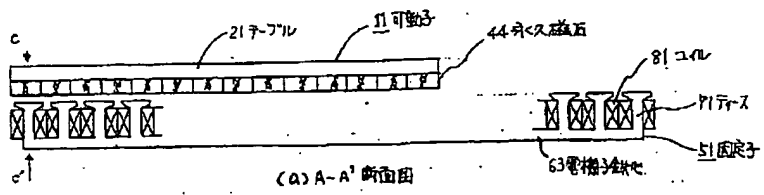
(a) A-A' 断面图



(b) B-B' 断面图



(C) 軸方向断面図



[Translation done.]